Locations and Forms of Reserve Nitrogen Available for Sprouting and Initial Growth of Spring Shoots in Satsuma Mandarin

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It is well known already that the reserve nitrogen in fruit trees constitutes a large portion of nitrogen to be used for sprouting and initial growth of spring shoots. With deciduous fruit trees, apple and peach, Oland and Yemm[6], and Baxter[1] made clear that it was the reserve nitrogen stored in roots and trunks. Yokomizo et al.[12] also expressed the same point of view. Further, Mochizuki[5] reported with apple that the nitrogen translocated from nitrogenous reserves constitutes a major portion of nitrogen supplied to new leaves at an initial leafing stage, but in a later stage the portion of nitrogen newly absorbed by plants increases. From an experiment using ^{15}N with citrus, Wallace et al.[10] made clear that only 15% of the total nitrogen in spring leaves of navel orange just at the end of leafing comes from fertilizers applied in the spring season. The present author and his co-workers[4] carried out an experiment in which ^{15}N-labelled nitrate was applied to soil as a spring manuring to satsuma mandarin. The result indicated that about 10% of nitrogen in the sprouting shoot was derived from the fertilizer applied and even in an early July when the spring leaves were almost completed the share of fertilizer nitrogen was barely 19%. Thus, it is usual that the dependence of nitrogen required for new shooting on the existing reserve nitrogen in plants is high except in case when nitrogen was heavily applied as a spring manuring[2]. Results of studies on the locations and forms of reserve nitrogen in satsuma mandarine will be presented as follows:

Locations of reserve nitrogen

To know kinds of organ as the source of supplying nitrogen for reutilization, and the extent of contribution of each organs, non-bearing trees of 4 years of age were grown

Table 1. Changes in total nitrogen content of different organs of Satsuma mandarin as related to the sprouting and subsequent initial growth of spring shoots

	1 Dec.	2 June (next year)	June / Dec.
New shoots	%	%	%
New leaves	—	2.92	—
New branches	—	1.91	—
1 year old leaves (emerged in previous year)			
Summer leaves	3.51	2.88	82
Spring leaves	3.56	2.65	75
1 year old brances (sprouted in previous year)			
Summer branches	1.67	1.35	81
Spring branches	1.46	1.23	84
2-3 year old branches	1.20	0.85	71
Trunks (4 year old)	0.97	0.87	89
Roots			
Main roots	1.21	1.10	91
Medium roots	1.90	1.55	82
Small roots	3.26	2.53	78

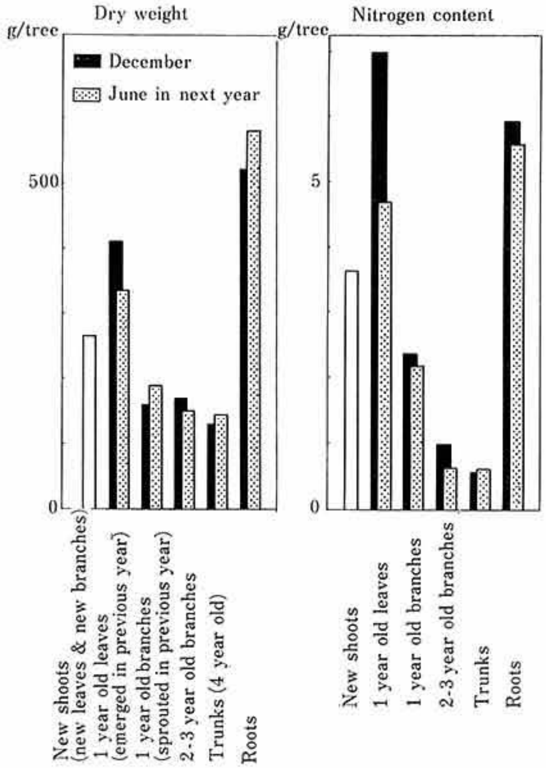

Fig. 1. Locations of reserve nitrogen consumed for sprouting and initial growth of spring shoots.

by the gravel culture method. During a period from early December to late June, nitrogen in the culture solution was kept at a low concentration, 2–3 ppm. Nitrogen contents of both new and old organs before and after the treatment period were given in Table 1. The organs which showed marked reduction in nitrogen content was so-called one-year-old leaves which emerged in the previous year, followed by roots, particularly rootlets, and branches of 2–3 years of age. Decreases or increases of the amount of nitrogen contained in different organs are shown in Fig. 1. Organs which showed a decrease in nitrogen amount beyond the changes of dry weight were branches of 1–2 years of age. Among which the nitrogen amount decreased in the one-year-old leaves was close to the nitrogen amount contained in new leaves which has the highest nitrogen requirement among newly developed organs. Nitrogen contained in roots was largely consumed for producing new roots, and relatively small quantity was translocated to new shoot, except in case of trees with particularly high level of nitrogen content.

Forms of nitrogen in one-year-old leaves, that was re-used

Changes in contents of different forms of nitrogen contained in one-year-old leaves of 4 year old trees, grown by the gravel culture at nitrogen concentration of culture solution regarded as a standard, were determined in the early March, before sprouting, and in the early June, when new shoots well elongated. As shown in Table 2, nitrogen content of one-year-old leaves lowered considerably from that in March to that of June, like a general trend observed in orchards. Among nitrogen fractions, protein N, both hot-water insoluble and soluble, showed no appreciable change in content. Among soluble N, soluble non-protein N, which constituted major portion of it, decreased remarkably. This fraction is made of free amino acids, inorganic N, etc.

Proportion of soluble N in the total N is very high with citrus, as compared to other fruit trees, especially deciduous trees, as is well known[10]. The range of seasonal fluctuations of soluble N is very large, as seen in Table 2–1: a high level of nearly 50% observed in winter to early spring decreased rapidly with the sprouting of new shoots. As stated above, the main portion of the soluble N is soluble non-protein N, most of which is composed of free amino acids. The free amino acids also showed a great seasonal fluctuation as shown in Table 2–2. The major free amino acids are proline in leaves, and proline and asparagine in rootlets. The amount of these amino acids decreases remarkably at the time of sprouting and initial growth of new shoots. During a period from March to June, the amount of free proline N decreased was

Table 2-1. Changes in different forms of nitrogen in 1 year old leaves according to the sprouting and initial growth of spring shoots

	Before sprouting 8 March	After leafing completed 2 June	
		medium N level	High N level
Total nitrogen (% d.w.)	3.30	2.82	3.83
Hot water soluble nitrogen (% d.w.)	1.76	1.71	1.86
Hot water insoluble nitrogen (% d.w.)	1.54	1.11	1.97
Protein nitrogen	0.22	0.23	0.26
Non-protein nitrogen	1.32	0.88	1.71

Table 2-2. Changes in amino acids (the same material as in Table 2-1)

	Before sprouting 8 March	After leafing completed 2 June
Amino acids (μ moles/g d.w.)		
Arginine	5.4	7.7
Aspartic acid	2.0	3.6
Serine fraction*	11.0	29.8
Glutamic acid	1.0	0.6
Proline	217.2	57.9
Alanine	16.2	5.7
Valine	2.7	2.7
Total	261.7	114.2
Total nitrogen (% d.w.)	3.30	2.82
Water soluble N/Total N(%)	47	39

* including amides

calculated to be 0.22g/100g of dry weight of one-year-old leaves, using the figures in Table 2-2. On the other hand, the amount of soluble non-protein N decreased during the same period was 0.43g/100g dry weight.

From the above results and calculations, it is considered that the free amino acids, especially proline, in leaves are closely related to the nitrogen requirement of new shoots for sprouting and initial growth. These free amino acids accumulate in autumn when temperature goes down, but what is the source is not yet known.

In relation to the phenomena that the free amino acids are regarded as the nitrogen source for spring shoots, Sagisaka observed with mulberry trees that the large amount of proline and arginine accumulated in wintering branches, and when the sprouting and elongation of spring shoots began proline disappears at first[8]. He observed also with poplar that free arginine decreased at the time of sprouting of small branches[7]. He considered that the accumulation of arginine before the sprouting may have such an advantage that an arginine molecule holds 4 organic nitrogen in the form of amino group and guanydyl group, and is easily transformed to other kinds of amino acids[7], while a proline molecule contains only one imino nitrogen and takes time for the transformation[11]. Therefore, it is hardly denied that proline is inferior to arginine, as the reserve form of nitrogen, but, on the other hand, it can be said that proline has a superiority not to be overlooked, i.e., it is akin to glutamic acid which is a key compound in the nitrogen metabolism[9].

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